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INFLUENCE OF TOOL PIN GEOMETRY ON FRICTION STIR WELDED DISSIMILAR ALUMINIUM ALLOYS - (AA5083 & AA6061)

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ABSTRACT

The present examination focuses on the evaluation of process parameters on mechanical properties and microstructure study of Friction stir welded (FSW) unlike Aluminum alloys. Their extent of use is in naval and marine applications. Dissimilar FSWed joints were fabricated by varying the rotation speeds, transverse speed and keeping tool geometry as taper with threaded pin profile. The welding parameters & tool probe geometry amusement play larger role in deciding the weld quality. While conducting FSW process, Al 5083 is positioned in advancing side and Al 6061on the retreating side. The experimental results have exposed that the sound defect free the joints obtained by varying the process parameters. From the achieved results, it is to be observed that eminent properties are acquired at a pivot rotational speed of 900rpm, and welding velocity at 40mm/min due to refinement of microstructure. The perceived outcomes were correlated with the microstructure and crack highlights.

***KEYWORDS:** Friction Stir Welding, Different Al Alloys, Pin Geometry, Microstructure & Mechanical Properties*

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Original Article

INTRODUCTION

Friction stir Welding is the sort of welding, utilized as a solid state joining process for materials that is distinctive composites of aluminum, magnesium etc., and as well for hard materials similar to steels as it deflects the common problems obtained in conventional welding processes. A Friction stir welding tool is a critical component to the achievement of the process. Friction stir welding (FSW) is a joining process, in which a non-consumable device is used to join two workpieces without softening the workpiece material. [1-2] Friction is generated because of rubbing stuck between the rotating tool & the workpiece material, which prompts to a softened region close to the FSW tool. The tool is traversed along the joint. It instinctively intermixes the two workpieces and compresses the hot and diminished metal by utilizing the mechanical force, which is acted by the tool. It is basically utilized on wrought or extruded aluminium alloys, and especially for structures which require very high weld quality [3-4]. The impact of the process limits such as rotational speed (V) and welding.

Speed (ν), tool probe profile on weld joint properties and microstructure has been explored in this present examination [5-6]. The objective of this paper is to distinguish the important process and FSW parameters on mechanical properties of AA6061 and AA5083, unlike aluminium alloys in FSW process.

H. Jamshidi Aval et al [8] examined that instrument geometry has assumes a crucial part on elasticity, prolongation, yield quality and hardness of the welded joint manufactured utilizing two dissimilar aluminum alloys 5086– 6061. They found that concave shoulder instrument comprising of cone shaped test engraved with three grooves created better outcomes when compared with other tools.

Zhao et al. [9] considered the pin geometry effect on mechanical properties of friction stir welded 2014 aluminum compound. It was construed that, the pin profile impacts the surge of the plastic material and the best quality weld was gotten using the decrease apparatus with screw string.

M. Ilangovan et al[10] in his examination, an endeavor has been made to weld the (AA 6061) and (AA 5086) aluminum combinations by friction stir welding (FSW) process, utilizing three different tool probe profiles like straight cylinder, taper cylindrical & threaded cylindrical. The elastic properties and micro hardness were assessed for welded joint. From this examination, it is recognized that the utilization of threaded probe profile adds to better stream of materials between two composites and the creation of defect free stir zone.

P. Satish Kumar et al[12] analyzed the Influence of Tool Rotational speed on Mechanical Properties of Friction Stir Welded 5083Aluminum composite. It is seen that at revolution speed of 710 rpm & 40 mm/min traverse speed with decrease with threaded profile brought about great mechanical properties.

A. Devaraju et al[13] in their running work, the impact of well Post-weld speedy cooling on Grain estimate and Mechanical properties of Friction Stir Welded AA 2014 was examined. The welding parameters and tool probe profile take part in significant jobs in choosing the welded joint quality.

M. Shiva Chander et al[14] in their current work, the impact of cryogenic (fluid nitrogen) cooling on grain size and impact of microstructure on Friction mix welded (FSW) unique Aluminum 5083 and 6061 composites were contemplated, because of their scope of utilization in maritime and marine applications. It was seen that improved mechanical properties were achieved at rotational speed of 900rpm and welding velocity of 31.5mm/min, the fine microstructure is acquired.

A. Devaraju et al[16] in the examination, the joining of unique AA2024 and AA7075 aluminum plates of 6 mm thickness was completed by friction stir welding (FSW) procedure. In the present examination, the high quality AA2024 T3 and 7075-T6 were welded by the FSW procedure, to certain the ideal mechanical properties by altering the rotational speed from 900 to 1400 rpm and welding speed between 30 to 60 mm/min. Better mechanical properties were obtained using square probe profile tool at a pivot speed at 1400rpm and welding pace of 60mm/min.

EXPERIMENTAL WORK

At initial a support metal of 5 mm thick AA5083-AA 6061 aluminum composites was jointed as butt-joint. Under vertical processing, the weld was happening on machine having 1 HP engine and 3000 rpm. H13tool steel was used, as it has Non-distorting qualities and having high hot hardness. Dimensions of tool shoulder and probe used are 24mm, 8mm, &length of stick 4.7 mm. The FSW process parameter is shown in table 1.A consistent pivotal power of 5 KN has been connected with three revolving and traversing speeds at tool profile (taper with threaded) for staying all FSW joints [8-9]. As soon as the fulfillment of welding, pieces were sliced for various tests (tensile, impact test (charpy), micro hardness, & micro structure) as indicated by ASTM principles.

Figure 1: FSW of Aluminium 5083 and 6061 Plates

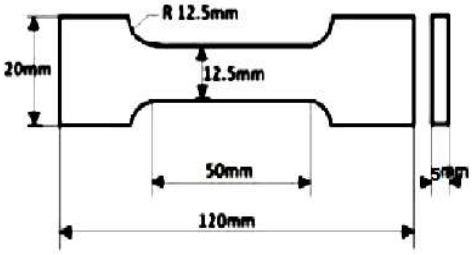

Figure 2: Tensile Test Specimen

A steady axial load of 5KN was applied with three rotational & welding speeds with tool profile (taper threaded) for left FSW joints. Experiments were coordinated with taper threaded pin profile on 5083-6061 Aluminum alloy combination with unlike tool rotational speeds at 710 rpm, 900 rpm and 1400 rpm, and also traversing speed of 40 mm/min, correspondingly. The examinations were passed on out on a Vertical milling machine (Make HMT FM-2, 10 hp, 3000 rpm) shown in Figure 1.

After completion of FSW, microstructural perceptions were done at the cross section of Nugget Zone of weldments. This surface could be mechanically cleaned and imprinted with Keller's reagent (2.0 ml HF, 3.0 ml HCl, 20 ml HNO3, 175 ml H2O) by means of optical microscope (OM) [10-11]. And, tensile tests were experienced by utilizing a universal testing machine. Micro-hardness tests were completed at the cross section of nugget zone (NZ) by utilizing Vickers digital micro-hardness analyzer.

Table 1: FSW Process Parameters

Test Piece	Tool Probe Profile	Revolving Speed (rpm)	Traversing Speed (mm/min)
1	Taper with thread	710	40
2		900	40
3		1400	40

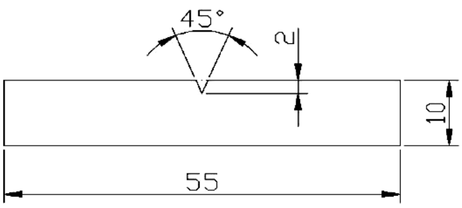

Figure 3: a) Impact Test Specimen b) Impact Test Machine

RESULTS AND DISCUSSIONS

Mechanical Properties

The tensile pieces were extricated from each joint. These pieces were tested utilizing universal testing machine (UTM) equal to ASTME 8-04 guidelines shown in figure 2.

The tensile properties like yield strength(YS), ultimate tensile strength (UTS) and level of prolongation, of friction stir welded AA6061 & AA5083 alloy welded pieces were assessed with taper with threaded tool profile. The outcomes demonstrate that the tensile properties of the welded pieces are basically changed as to different probe profiles. A higher tensile strength of 191.62 MPa was acquired in the joint made by taper with threaded pin profiled tool at 900 rpm and welding speed of 31.5 mm/min. A low tensile strength of 126.16 MPa was accomplished in the joint, welded by taper with threaded pin profiled tool at 710 rpm and welding speed of 40 mm/min. This might be because of the impact of well grain arrangement during the fabrication process [13].

The % elongation of taper with thread tool is 7.32 %, and this is correlated with the yield stress at the tool revolving speed of 900 rpm and traversing speed of 40 mm/min. There is a hike of deformation, which is expected due to the microstructure variations in the mix zone & the ideal proof stress was obtained as 123.65 MPa with taper threaded tool profile, differentiated to other joints. The results obtained and have shown in table 2.

Table 2: Mechanical Properties of Friction Stir Welded 5083 & 6061 Aluminium Plates

Specimen	Tool Rotation Speed (rpm)	Hardness (HV)	Ultimate Tensile Strength (MPa)	Yield Strength (MPa)	% of Elongation	Impact (J)
1	710	70.13	138.94	90.86	2.7	14
2	900	73.3	191.62	139.65	7.32	32
3	1400	66.87	127.67	92.13	1.97	18

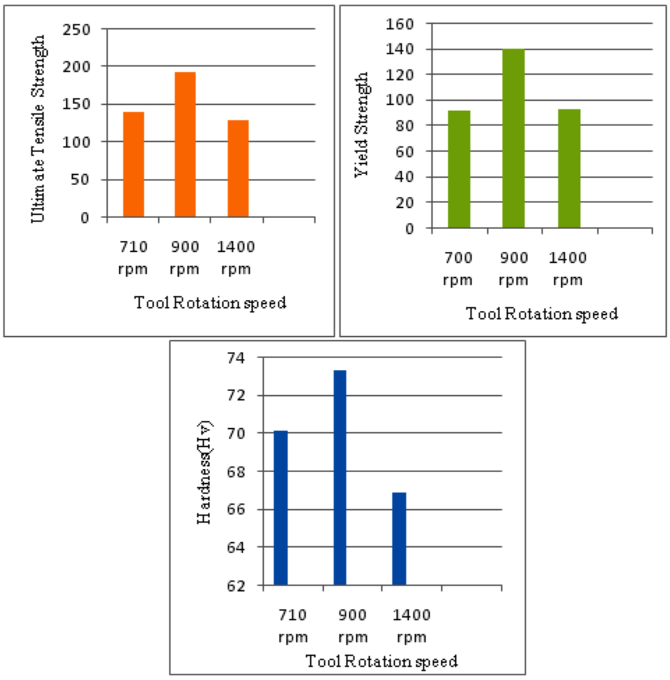

Figure 4: a) Tool Rotation Speed Vs Ultimate Tensile Strength
b) Tool Rotation Speed Vs Yield Strength
c) Tool Rotation Speed Vs Hardness

Microstructural Observation

On the basis of microstructural characterization of grains and precipitates, 3 unique zones developed named as,

- Nugget (stirred) zone
- Thermo-mechanically influenced zone (TMAZ)
- Heat affected zone (HAZ).

Observations made that the joints made at condition 900 rpm and with traverse speed of 40mm/min resulted in extremely smaller equi-axed grains differentiated to a base material [14]. The images of these microstructures are projected at a magnification of 100x. The micro structure piece was taken from every sample from its NG. The specimen's NG was fabulous, wrapped by utilizing various emery papers, and lastly brought it into mirror image[16]. At that point, after we go for etching, we utilize Keller's reagent (2.0 ml HF, 3.0 ml HCL, 20.0 ml HNO3 and 175 ml H2O).

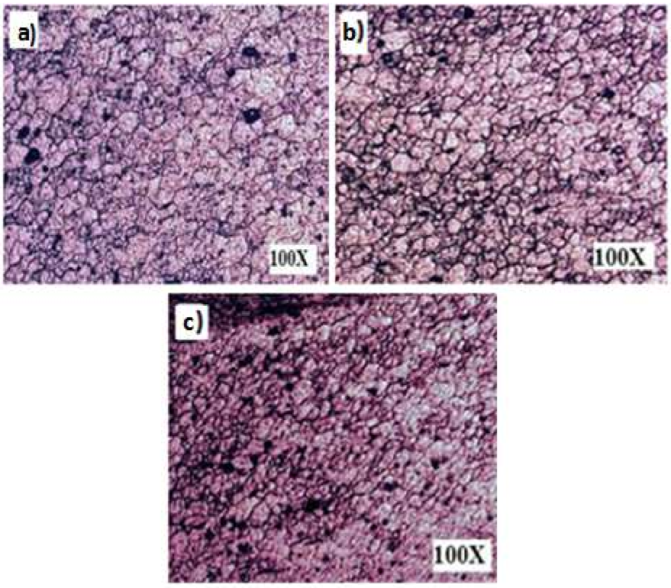

Figure 5: Microstructures for Tool Rotation Speeds at 710 rpm, 900 rpm and 1400 rpm

CONCLUSIONS

From the above discussions, it is clear that the impact of different tool profiles and various process parameters on mechanical properties and microstructure influences incredibly as shown below.

- It is to be seen that higher mechanical properties were acquired at 900 rpm with welding pace of 40 mm/min i.e., 191.62 MPa(UTS) by utilizing taper with threaded tool profile. And, the microstructure is additionally related with the accomplished mechanical properties.
- Poor mechanical properties like UTS, % elongation and impact strength were acquired at 710 rpm with a traversing speed of 40 mm/min by using taper threaded tool probe profile.
- A fine and equiaxed grain microstructure procured at 900 rpm and 40 mm/min traversing speed and a poor microstructure got at 1400 rpm.
- The highest hardness value is 73.3 Hv at a rotational speed of 900 rpm due to the excess frictional heat generated at this condition.

- The impact strength is 32 J at a revolving speed of 900 rpm and welding speed of 40 mm/min, and is correlated with the ultimate tensile strength value 191.62 MPa.
- From the results, it is clear that the optimum process parameters at 900 rpm and welding speed 40 mm/min with taper threaded tool profile were better for FSW of 5083 and 6061 dissimilar joints.

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